

Utilisation of Water Purification “Tablets” at Household Level in Namibia and Tanzania

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Abstract

Generally disinfection of water at household level can be achieved using several soluble tablets or chemicals which have been proven to render water to be microbiologically safe. The use of disinfectants at household levels has been reported to contribute to the reduction of waterborne diseases in areas with limited supply of piped water. Water guard is produced and widely used in Tanzania especially in the rural and informal settlements; whilst in Namibia, water marker and Aqua tabs are imported and distributed to similar communities. Sodium Hypochlorite, a chlorine base chemical which is either in powder or tablet form is widely used in the two countries. Through informed consent community volunteers were used for the collection of water from shallow wells, which was subsequently treated and analysed in Tanzania. Volunteers were also asked about their methods of water treatment and storage. In Namibia, information on appropriate use of purification chemicals at household level was obtained through desktop review and key informants. The aim of this study was to investigate the effectiveness and proper utilisation of the water purification chemicals at household level in the two countries. The appropriate use of chemical doses provides 100% disinfection efficiency with chlorine residue of less than 0.3 mg/l which is within the recommended limits for WHO. The authors conclude that household water purification chemicals are effective against pathogens; however the chemicals' effectiveness depends on appropriate use in terms of mixing, handling and hygiene of container used. A common problem experienced by Namibia and Tanzania is related to improper mixing, which affects the taste of water, and thus influences the user's choice of prolonged use.

Keywords

Water Guard, Water Marker, Aqua Tabs, Pathogens, Effectiveness, Disinfection, Residue Chlorine

1. Introduction

Access to safe drinking water is one of the Millennium Development Goals [1]. While piped water supply is an important long-term goal for many developing countries including Tanzania and Namibia, the WHO and UNICEF acknowledge that it is unlikely to meet the MDG target of halving the proportion of the people without sustainable access to safe drinking water and basic sanitation by 2015. Water quality is further compromised by waterborne pathogens and storage at household level. Diarrheal diseases are a major cause of morbidity and mortality among children younger than five years of age, largely because of inadequate water treatment and lack of sanitation [2]. According to the most recent World Health Organization/United Nations Children's Fund Joint Monitoring Programme for Water Supply and Sanitation data, only 10 percent of Tanzanians use improved sanitation facilities, 70 percent use unimproved facilities, and 12 percent practice open defecation [3].

Namibia has not managed to supply all of its population with piped water, which is considered the best method of alleviating water borne related illness. A large portion of population use water from other sources such as boreholes, wells and rivers. The quality and safety of such water sources is poor, and thus affecting the public health. Some of the country challenges in water and sanitation are: limited access to potable water and sanitation services; and lack of empirical evidence on the impact of point of use water treatment methods is also concerning.

Household-based water treatment is thus considered as one of the main alternative interventions that can deliver the health gains of safe drinking water at lower cost. The application of disinfecting chemicals is essential in order to prevent water borne diseases whose transmission route is by oral ingestion. Sodium hypochlorite with a trade name WaterGuard, a disinfecting chemical which kills micro organisms when applied in contaminated water has been identified as an effective water treatment chemical for domestic use [4] [5]. Consistent use of WaterGuard has also proved to be effective in controlling some types of waterborne diseases like cholera, diarrhea and typhoid [6]. WaterGuard[®] was designed by CDC in conjunction with PSI and CARE International for water disinfection. It consists of 1% Sodium Hypochlorite (NaOCl) solution [2].

A WHO systematic review found that among all water quality interventions, household-based chlorination is the most cost-effective [7]. Chlorine has been used all around the world to treat water for over 100 years now and it is still trusted by the World Health Organization (WHO) for that capability [2].

Safe Water System (SWS) is also an intervention by Centre for Disease Control and Prevention (CDC). The system was developed as an inexpensive, appropriate means to reduce risk of diarrhea in the developing world. The SWS comprises chlorine water treatment at the point of use, storage of water in a safe container, and education to improve hygiene and water use practices. The SWS has been shown to decrease the risk of diarrhea by 24% to 85% [8] and has been implemented in over 20 countries; including African countries like Malawi, where the health workers and WaterGuard vendors interviewed felt there was a need to raise awareness and promote safe storage, handling, and treatment practices in the community. They also agreed on the need for more promotional materials, such as posters and product samples, and ongoing awareness campaigns [9].

A decline in utilization of water purification tablets including WaterGuard and Aqua Tablets has been identified in several countries including Malawi, Kenya, Tanzania and Namibia. In Malawi, the use of WaterGuard dropped to 28% after the free distribution period despite continued subsidized price. Previous WaterGuard use, availability of WaterGuard in the house, perception about vulnerability to diarrhoea and cholera, perception about water source and cost are the main factors that affect use of WaterGuard in the area [10].

The aim of this study was to investigate the effectiveness and proper utilisation of the water purification "tablets" at household level in the two countries. The appropriate use of chemicals doses provides 100% disinfection efficiency with chlorine residue of less than 0.3 mg/l which is within the recommended limits for WHO [11].

2. Materials and Methods

Secondary data from desktop study were used to determine water purification tablets' effectiveness and utilisation patterns, and to assess the past and current household water treatment initiatives by developing world countries, particularly Namibia and Tanzania. Different reports, articles, and websites were accessed. The data acquisition was purposive and based on keyword searches, footnote chases, citation searches, and journal runs.

Content analysis methods for drawing conclusions included noting patterns, themes and trends, making comparisons, building logical chain of evidence and making conceptual/theoretical coherence. The content analysis yielded some descriptive data giving a detailed picture of the effectiveness and utilisation of the water treatment tablets in Namibia and Tanzania.

3. Discussion of Results

3.1. Utilisation

Access to safe water and sanitation can help decrease the high prevalence of water-borne diseases, such as diarrhoea and cholera, in both urban and rural Tanzania. In 2002, PSI/Tanzania (in collaboration with the MOHSWS and Ministry for Water) launched a program for WaterGuard, a household water treatment solution. In 2005, WaterGuard became available in tablet form, which is more user-friendly due to longer shelf-life [6].

While half of the participants (in both the urban and rural areas) reported being familiar with and/or using WaterGuard in the past, none of the participants reporting currently using WaterGuard to treat their drinking water. Almost all of the participants who were familiar with WaterGuard reported not liking the smell; taste was also an issue in the rural areas. “I like boiling the best because the water does not remain with any smell compared to WaterGuard” (participant). According to the DHS survey, the most common water treatment method is boiling (30 percent), followed by straining through cloth (9 percent), and only a very few households (2 percent) use bleach or chlorine-based water treatment [12].

The majority of participants (12 out of 16) reported treating their drinking water by either boiling and/or filtering their water through a cloth. While these findings do not reflect the 2010 national Demographic and Health Survey (DHS) which showed that 60 percent of Tanzanians use no treatment method prior to drinking, our findings illustrate the potential geographical and source differences that are present in these types of surveys. All eight of the rural participants reported using some type of treatment method [12].

Factors affecting utilization of water treatment methods can also be confounded by availability/coverage and market penetration of the chemicals/tablets (also shown in **Table 1**). Coverage is the proportion of geographic units in which a minimum standard of product or service availability is present. The primary use of the coverage indicator is in determining whether proximity of populations to PSI products and services is increasing or decreasing over time [13]. Penetration is the proportion of outlets in which a product or service is available: out of all potential outlets for a given product or service, it is the percentage of outlets that actually sell the product or

Table 1. Percentage market penetration of WaterGuard products in Tanzania (Data source: [13]).

| | Year | Southern Zone | Coastal Zone | Central Zone | Lake Zone | Northern Zone | National | |
|--------------------|-------|---------------|--------------|--------------|-----------|---------------|----------|----|
| Waterguard Liquid | Rural | 2006 | 1 | 2 | 3 | 1 | 3 | 2 |
| | | 2007 | 4 | 8 | 2 | 6 | 0 | 3 |
| | | 2008 | 0 | 2 | 1 | 1 | 2 | 1 |
| | | 2009 | 0 | 4 | 6 | 5 | 1 | 4 |
| | Urban | 2008 | 1 | 22 | 8 | 18 | 3 | 10 |
| | | 2009 | 2 | 17 | 12 | 10 | 1 | 8 |
| Waterguard Tablets | Rural | 2006 | 3 | 5 | 3 | 4 | 3 | 4 |
| | | 2007 | 6 | 11 | 6 | 6 | 2 | 6 |
| | | 2008 | 10 | 32 | 2 | 8 | 4 | 10 |
| | | 2009 | 6 | 6 | 9 | 11 | 2 | 6 |
| | Urban | 2008 | 10 | 19 | 8 | 16 | 5 | 11 |
| | | 2009 | 3 | 15 | 11 | 12 | 1 | 8 |
| Any Waterguard | Rural | 2006 | 3 | 6 | 4 | 4 | 5 | 4 |
| | | 2007 | 9 | 15 | 7 | 4 | 2 | 7 |
| | | 2008 | 10 | 33 | 2 | 7 | 5 | 11 |
| | | 2009 | 6 | 7 | 9 | 14 | 3 | 7 |
| | Urban | 2008 | 10 | 26 | 11 | 24 | 6 | 15 |
| | | 2009 | 3 | 19 | 13 | 15 | 1 | 12 |

provide the service [13].

In the rural areas, Liquid WaterGuard was the least available product. WaterGuard tablets coverage appeared to be fairly stable with little variations noticed. Central Zone has recorded a higher rural coverage for WaterGuard tablets followed by Lake and coastal zone. The coverage of WaterGuard tablets and liquid combined indicates a slight decrease in rural coverage for WaterGuard—from 35% in 2008 to 28% in 2009 [13].

WaterGuard urban coverage was between 30% in Northern and Southern and 95% in Central zone. Most of the locations in urban Southern and Northern zone did not have water treatment kits—WaterGuard during the time of the survey. It is also important to note that, comparing the (2008) results and (2009), coverage performance for WaterGuard indicate to have increased across zones [13].

Availability of WaterGuard in urban locations has likely decreased, from 15% in 2008 to 12% in 2009. This decrease is noted for both WaterGuard tablets, which decreased from 11% in 2008 to 8% in 2009; and WaterGuard liquid, which decreased from 10% in 2008 to 8% in 2009. Experience in many countries suggests that social marketing is not sufficient to expand the use of home water treatment products; additional behavioral interventions are needed to increase long-term purchase and use [14]–[18].

Affordability is one of the key factors one should consider in selecting the household water treatment methods. Gadgil [19] reported that most of the household drinking safe storage and treatment technologies remain inaccessible by the majority in developing countries due to cost, which is not the case for Namibia, due to government efforts to supply the chemicals at no cost, which might also have long term supply shortfalls.

The Evidence Action research team identified and systematically removed barriers (cost, access, time, correct usage) to consistent utilization of WaterGuard tablets. At a follow-up visit after some 8 weeks, the dispenser group and the free distribution group both had about 50% adoption. This was a more than 6-fold increase over the control group, where adoption was about 7%. Most importantly, the dispenser adoption rate held steady, for two years, not falling off as the novelty of the product declined or as people learned more about it [20].

In Namibia, household treatment technologies are supplied to communities by the Ministry of Health and Social Services, through the office of District Environmental Health Practitioners and local pharmacies. Community health workers have been trained on the promotion of proper chemical use and water storage after treatment, and are entrusted with mobilisation and community education. The supply and utilization of water treatment chemicals is concentrated in the northern parts of the country, mainly Ohangwena, Kunene, Kavango and Zambezi regions, where piped water supply is limited to towns. The supply is usually intensified during droughts and floods seasons. During the 2013 drought, Hygiene kits were distributed in Epupa constituency in Kunene region a bucket and jerry can per 5-member family while aqua tabs were issued per individual, each individual was issued with consumption of 30 days. Pur sachets were issued on an individual basis as well; a sachet was issued per day for the duration of 30 days to the beneficiaries. Pur sachets were issued to beneficiaries with unprotected water sources while aqua tabs were issued to families with protected water sources but not treated [21]. According to Alekal [2], PuR[®] was designed by Proctor & Gamble Engineers to preserve a water treatment plant and to provide high quality drinking water at the point-of-use. PuR[®] consists of Ferric Sulfate ($\text{Fe}_2(\text{SO}_4)_3$) for coagulation and Calcium Hypochlorite ($\text{Ca}(\text{OCl})_2$) for disinfection. PuR[®] is important where there are naturally high turbidity levels in surface and groundwater.

In Ohangwena, Water purification tablets have been distributed to 21,000 beneficiaries in 49 villages in Okongo constituency, while in Omundaungilo, water purification tablets were distributed to 500 beneficiaries. 20,000 sachets of water purification tablets donated to councilors of Oshikango and Omundaungilo constituencies are due to be distributed [21].

3.2. Effectiveness of the Household Water Treatment

Yohana and Mashauri [11] described Water Guard as a disinfecting chemical which kills micro organism when applied in contaminated water; and which oxidizes organic matter if the treated water is turbid and contains organic content. The purpose of disinfecting raw water is to destroy pathogenic organisms and thereby eliminate and prevent waterborne diseases like typhoid, Diarrhea, Cholera, and amoebic dysentery. Water guard is one of the many disinfectants applied in the course of water treatment process whose chemical name is sodium hypochlorite and other common names include liquid bleach or soda beach, with a 74.5 relative molecular mass and an empirical formula NaClO . Sodium hypochlorite may be prepared by absorbing chlorine gas in cold sodium hydroxide solution (as shown in Chemical Equation (1)):



Sodium hypochlorite is a salt of hypochlorous acid. In water, it completely dissociates into the sodium cation Na^+ and the hypochlorite anion ClO^- while a small portion hydrolyses into sodium hydroxide and hypochlorous acid (as shown in Chemical Equation (2)) [22]:



The chemical reactions verified between organic tissue and sodium hypochlorite are explained by Yohana and Mashauri [11] as saponification, amino acid neutralization, and chloramination reaction. The chloramination reaction between chlorine and the amino group (NH) forms chloramines that interfere in cell metabolism. Chlorine (strong oxidant) presents antimicrobial action inhibiting bacterial enzymes leading to an irreversible oxidation of SH groups (sulphydryl group) of essential bacterial enzymes.

It is worth noting that residue chlorine increases with dosage and decreases with increasing water turbidity; and that according to Mmbando [4], the effectiveness of water guard is also influenced by turbidity, pH Temperature water chemistry in question and contact time. Thus it is necessary to maintain a balance between the concentrations of water guard which can completely kill all the pathogens with permissible residue chlorine.

A study conducted by Mmbando [4] in Dar es Salaam city revealed that all collected well water samples showed no faecal coliforms only after a contact time of 5 minutes with the purification tablets. This indicate the higher inactivation rate of Water Guard dose of 0.375 ml/l, which is equivalent to 7.5 ml/l (a cup-full of Water Guard) in 20 litres of water given by the manufacturer. However its inactivation rate decreases as life span of a particular batch decreases, which cause increase in contact time. A 16.7% solution stored at 26.70°C will lose 10% of its strength in 10 days, 20% in 25 days and 30% in 43 days [23]. Another study by Mwambete and Manyanga [5] on investigating the microbial quality of drinking water in Dar es salaam and use of Water Guard as disinfectant, showed that, taps, streams and shallow wells water sources were all heavily contaminated with pathogens, but appropriate use of WaterGuard reduced the level of microbial contamination significantly. Yohana and Mashauri [11] found the assayed WaterGuard to be 100% efficacious in treating the samples to a level within the WHO safety standards as well as Tanzania standards, hence it was confirmed to be effective for disinfecting water for human use.

Aqua tabs have been distributed to most cholera prone communities within the Kunene Region of Namibia [21]. Attributes of aqua tabs include safe and easy storage and handling; as well as the capacity to dissolve quickly, with no evidence of objectionable odour or taste, as well as ability to reduce total and faecal coliforms in water. The tablets are active over wide ranges of pH, turbidity, hardness, and pathogenic challenge. The chemical is resistant to sunlight damages, offers single use packaging and its low weight packaging approach make it easy for distribution [24]. Clasen and Edmondson [25] reported that the use of household water treatment methods such as aqua tabs reduces the burden of Diarrhea in the community. It should be noted however, that the impact of household treatment in Namibia is not well established.

3.3. Water Purification for Economic Advancement

The significance of this study is on promoting consistent and efficient use of household water treatment reagents including purification tablets. The discussion above has direct benefits in terms of green economy. The green economy is an economic system in which economic growth is consistently linked with environmental sustainability. This economy increases amongst other things productivity and income, social equity, environmental protection, and improved public health. The roll out of chlorination tablets to communities accelerates access to safe water and has been affirmed to offer quick health returns and improve public health in low income communities [26]. The intervention presents economic benefits to the health sector in terms of reduction in health-related costs and improvement of labour force turnover; and increase in school attendance as a result of reduction in diarrheal cases [26] [27]. Access to safe drinking water at household level has also been proven to be accelerated by the rollout of household water treatment chemicals.

Although household water treatment intervention is reported as sustainable and beneficial to different communities, its sustainable implementation could be difficult to prove in Namibia and Tanzania, due to lack of monitoring data, and the ability and willingness of the communities to pay for the chemicals. Considering the irrefutable fact that the rollout of water purification tablets ensures equitable access to safe water, with additional benefit of empowerment to those entrusted to supply the chemical to others; the results of this study can be

used as baseline for chemical engineers to come up with less costly, more efficient and sustainable household water treatment methods.

4. Concluding Remarks

The authors conclude that the utilization and effectiveness of water purification tablets is affected by several factors including incorrect dosing leading to objectionable smell and taste, storage in direct sunlight, cost, and perceived benefit. It is thus appropriate to suggest that hygiene promotion should be improved at community level; use of water treatment tablets should be supplemented by continuous education and assessment on correct use, and monitoring and evaluation of the intervention to assess impact.

On the effectiveness, the authors conclude that, purification tablets are effective against pathogens. It is also concluded that the effectiveness of the tablets depend on appropriate use in terms of mixing, handling and hygiene of container used. Improper mixing affects the taste of water, which influence user's choice on continuous use, a problem which is experienced by both countries.

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